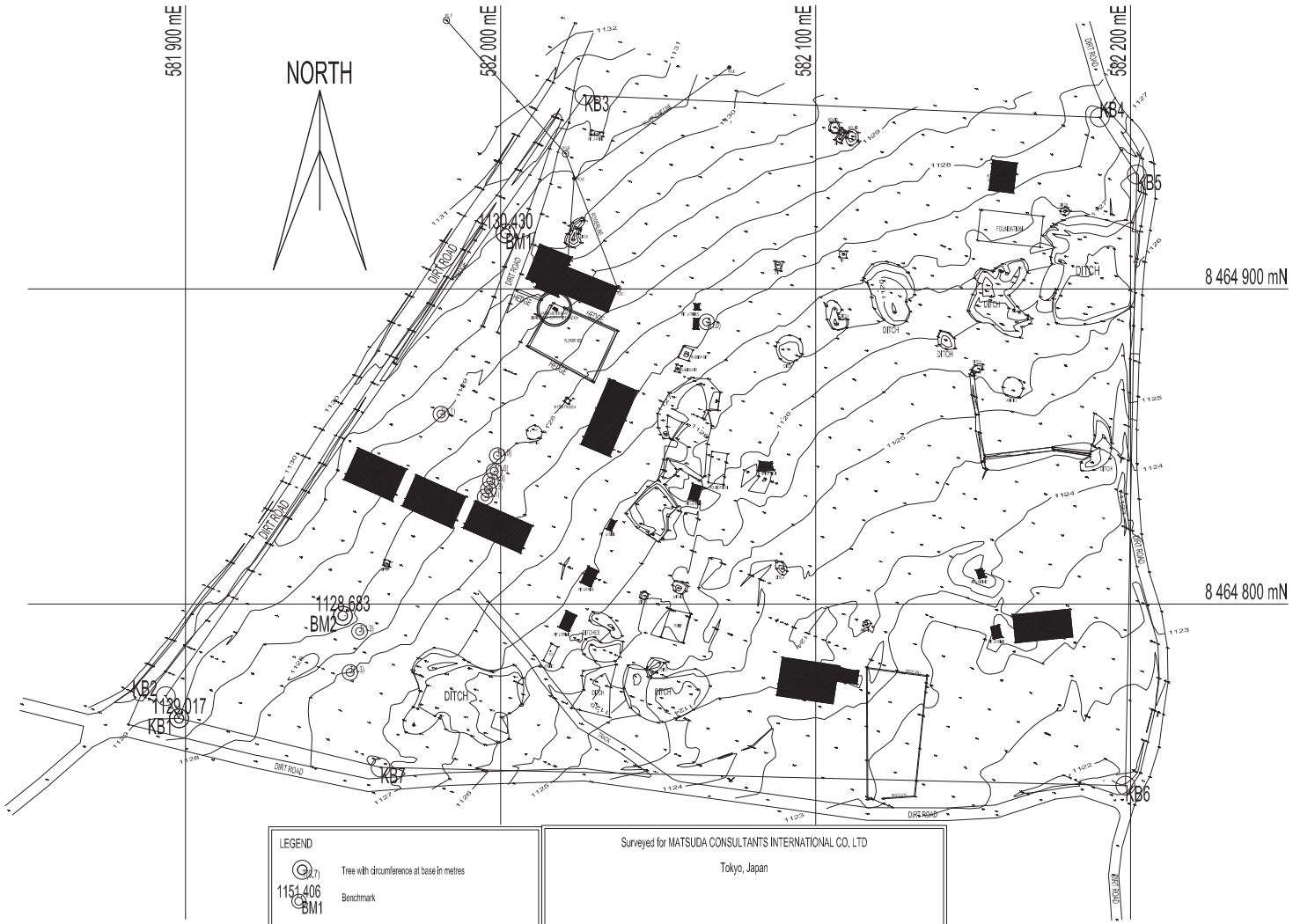
TOPOGRAPHICAL SURVEY OF KABWABWA COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 1130.430m (Iron peg in concrete)
BM2 1128.683m
KB1 1129.017m

CONTOUR INTERVAL : 0.5m



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			APPROVED BY :	SCALE : 1:1500		

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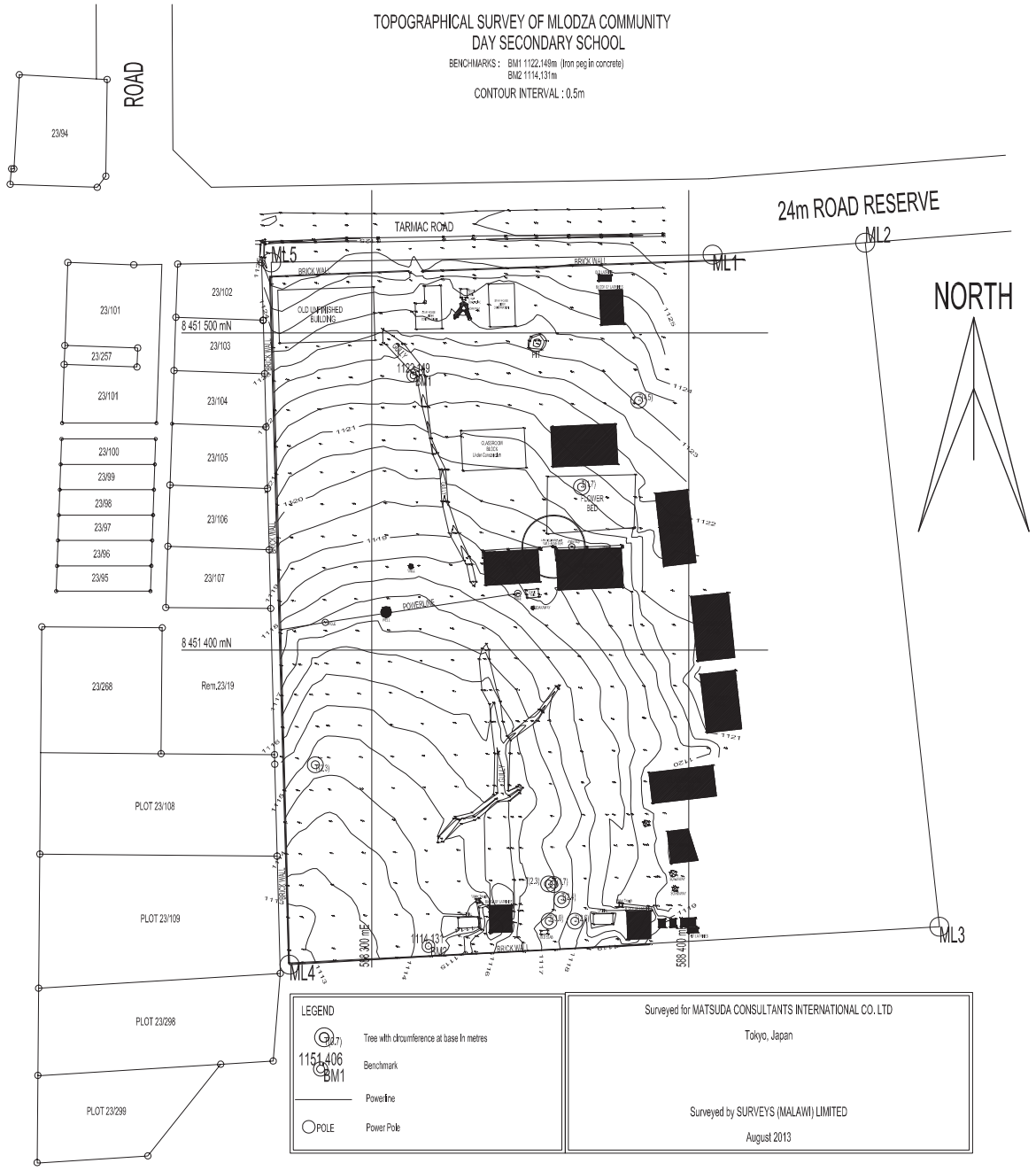
TOPOGRAPHICAL SURVEY OF MLODZA COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 1122.149m (Iron peg in concrete)
BM2 1114.131m

CONTOUR INTERVAL : 0.5m



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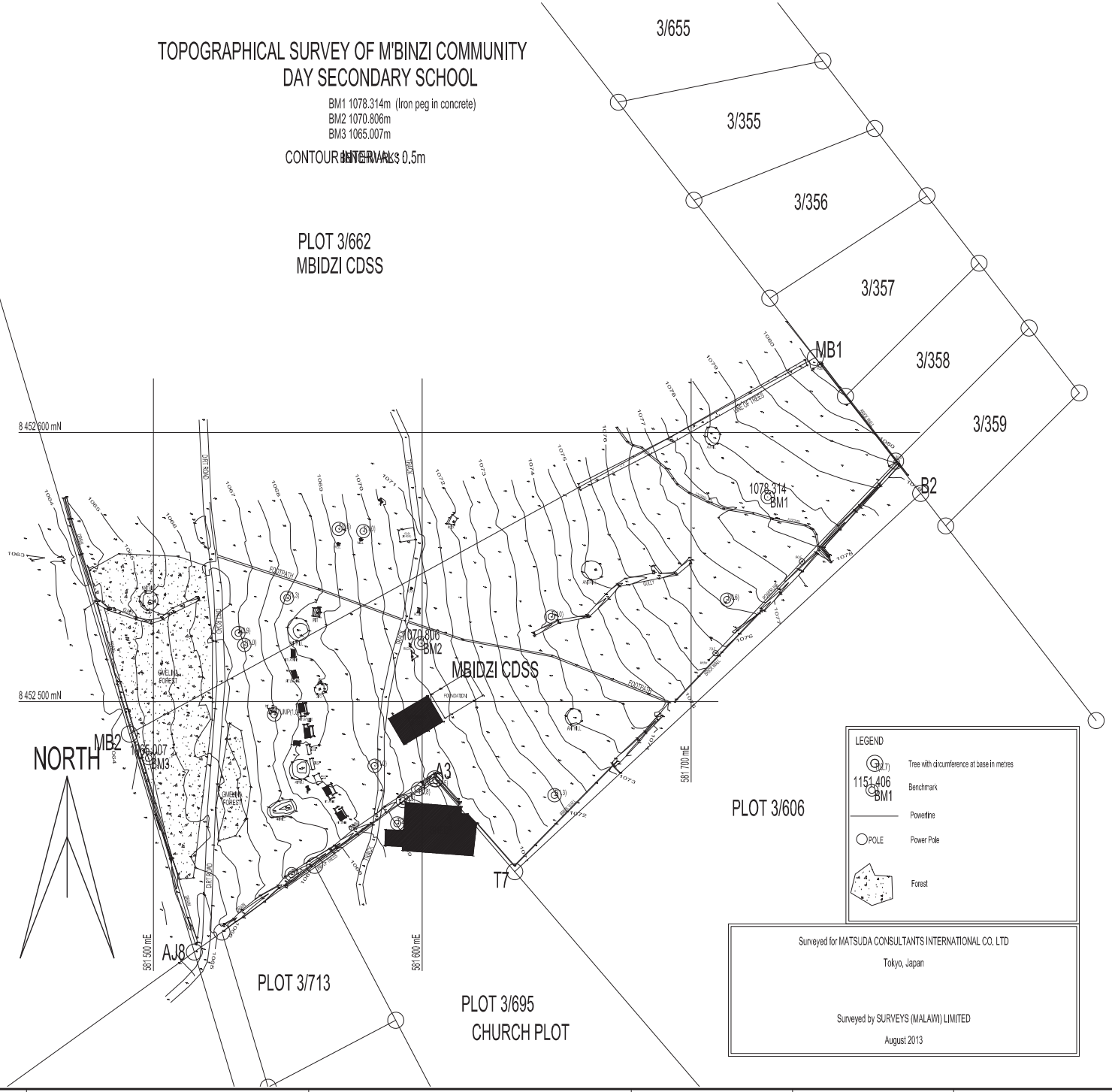
			APPROVED BY :	SCALE : 1:1500		

TOPOGRAPHICAL SURVEY OF M'BINZI COMMUNITY DAY SECONDARY SCHOOL

BM1 1078.314m (Iron peg in concrete)
BM2 1070.806m
BM3 1065.007m

CONTOUR INTERVALS 0.5m



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August 2013

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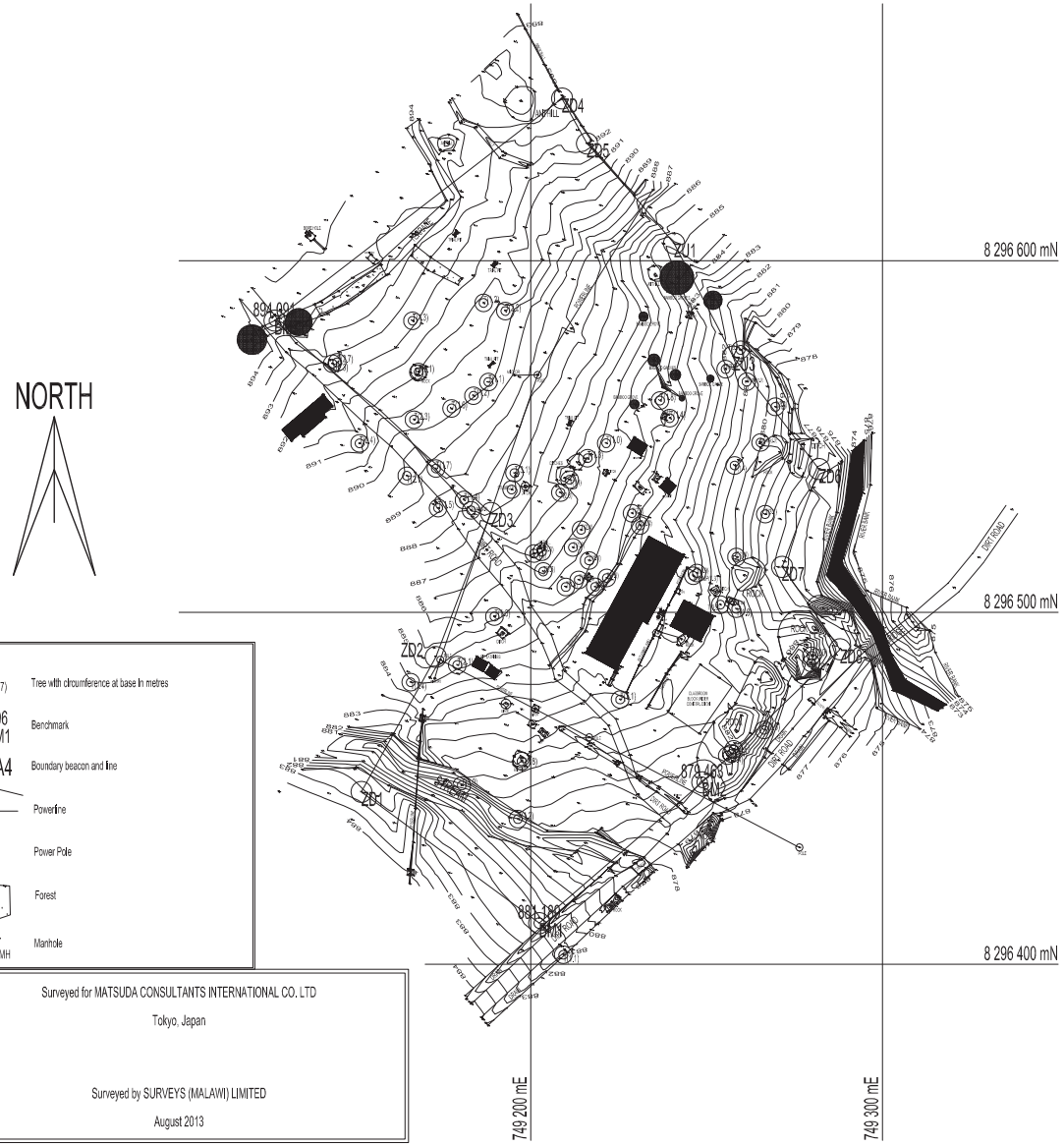
			APPROVED BY :	SCALE : 1:1500		

TOPOGRAPHICAL SURVEY OF ZOMBA URBAN COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 881.171m (Iron peg in concrete)
BM2 879.463m
BM3 894.056m

CONTOUR INTERVAL : 0.5m



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A40

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			APPROVED BY :	SCALE : 1:1000		

TOPOGRAPHICAL SURVEY OF UMBWI COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 1593.796m (Iron peg in concrete)
BM2 1596.795m
UM4 1593.146m
UM9 1599.159m

CONTOUR INTERVAL : 0.5m

LEGEND

(0.7)	Tree with circumference at base in metres
1151.406 BM1	Benchmark
MWA4	Boundary beacon and line
	Powerline
POLE	Power Pole
	Forest
MH	Manhole

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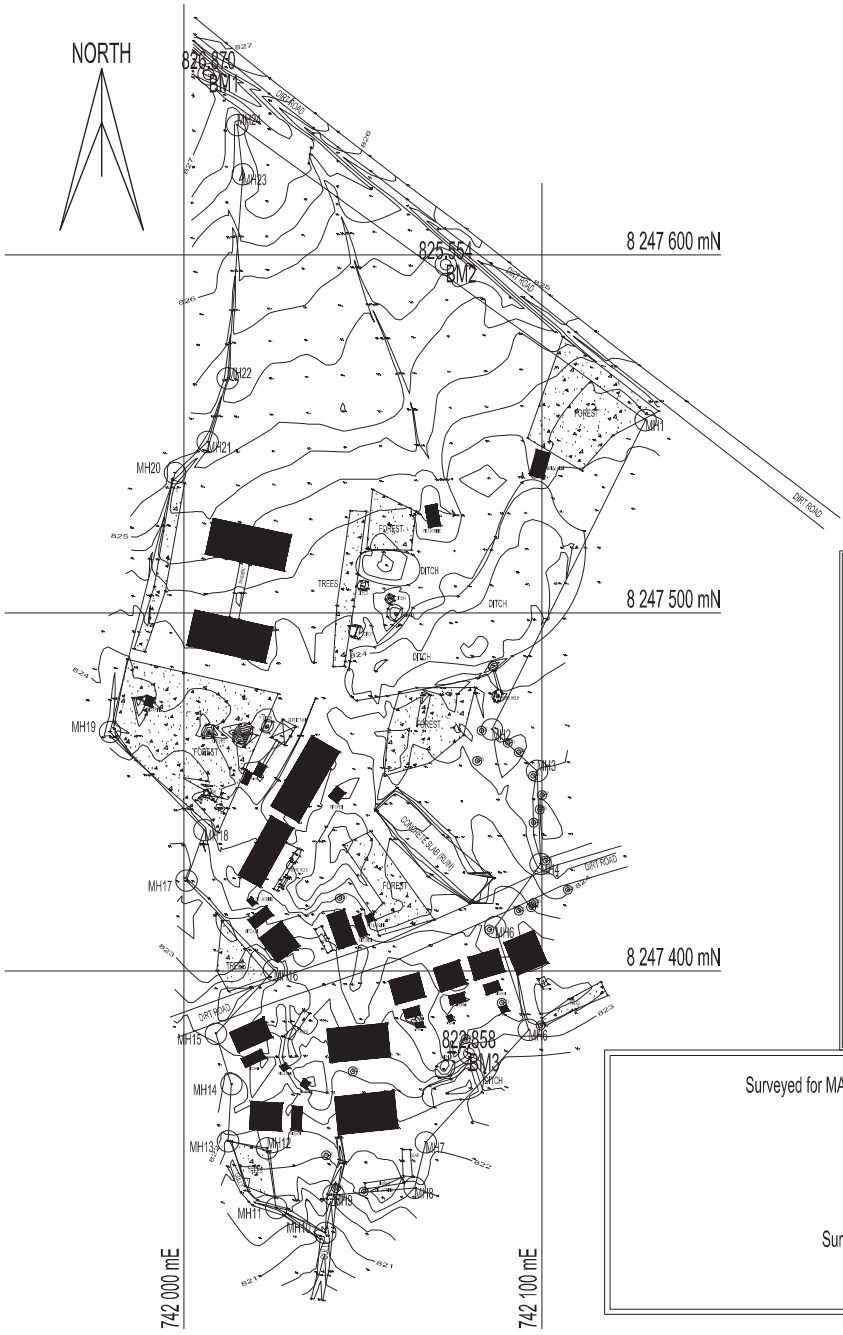
TOPOGRAPHICAL SURVEY OF MUHASUWA COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 826.870m (Iron peg in concrete)
BM2 825.554m
BM3 822.858m

CONTOUR INTERVAL : 0.25m



LEGEND

- Tree with circumference at base in metres (e.g. 0.7)
- 1151.406 BM1 — Benchmark
- MWA4 — Boundary beacon and line
- Forest

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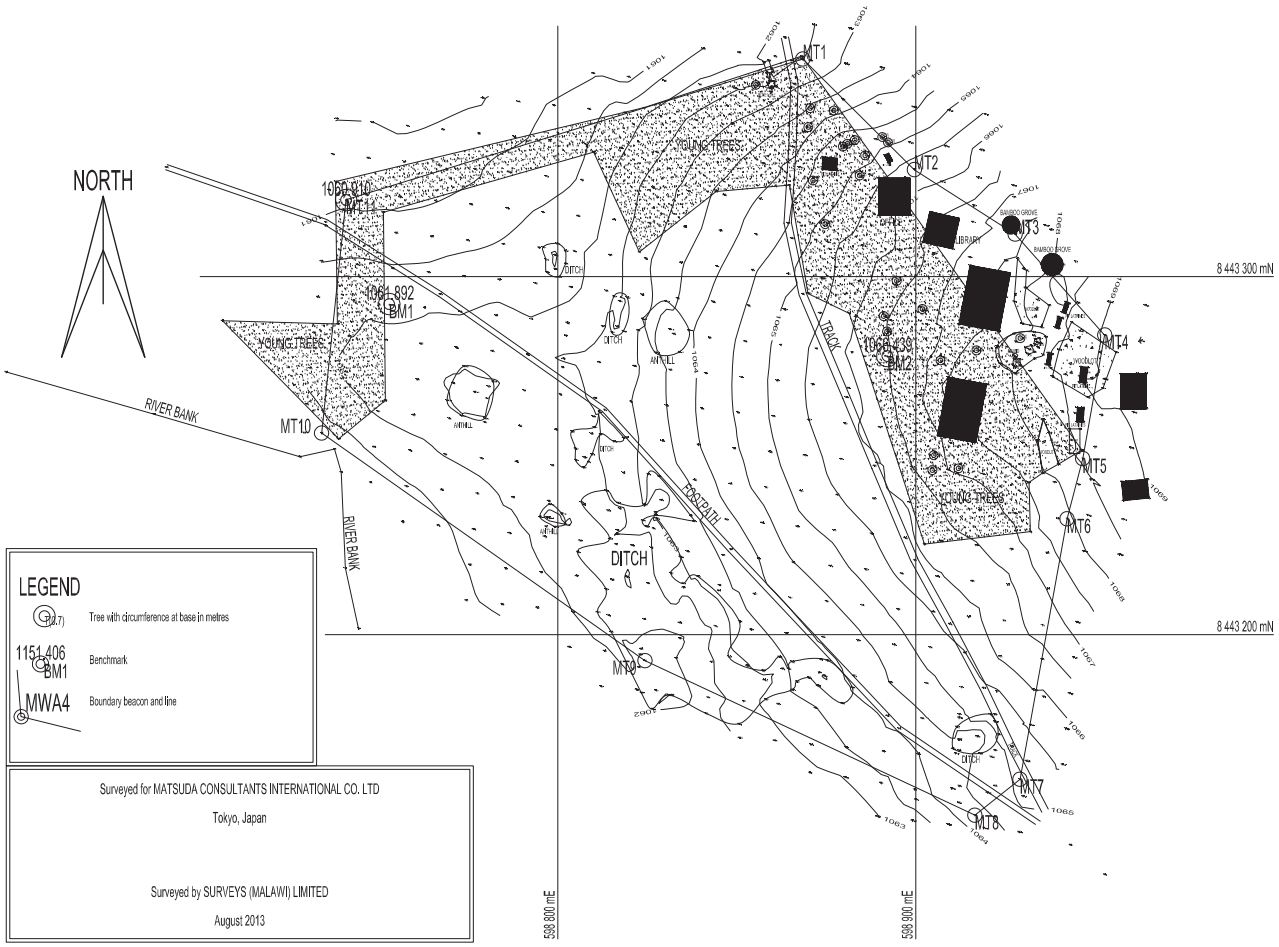
			CHECKED BY :	DATE : SEPT. 2013		
			APPROVED BY :	SCALE : 1:1500		

TOPOGRAPHICAL SURVEY OF MWATIBU COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 1,061.892m (Iron peg in concrete)
BM2 1,066.439m
MT11 1,060.910m

CONTOUR INTERVAL : 0.5m



A43

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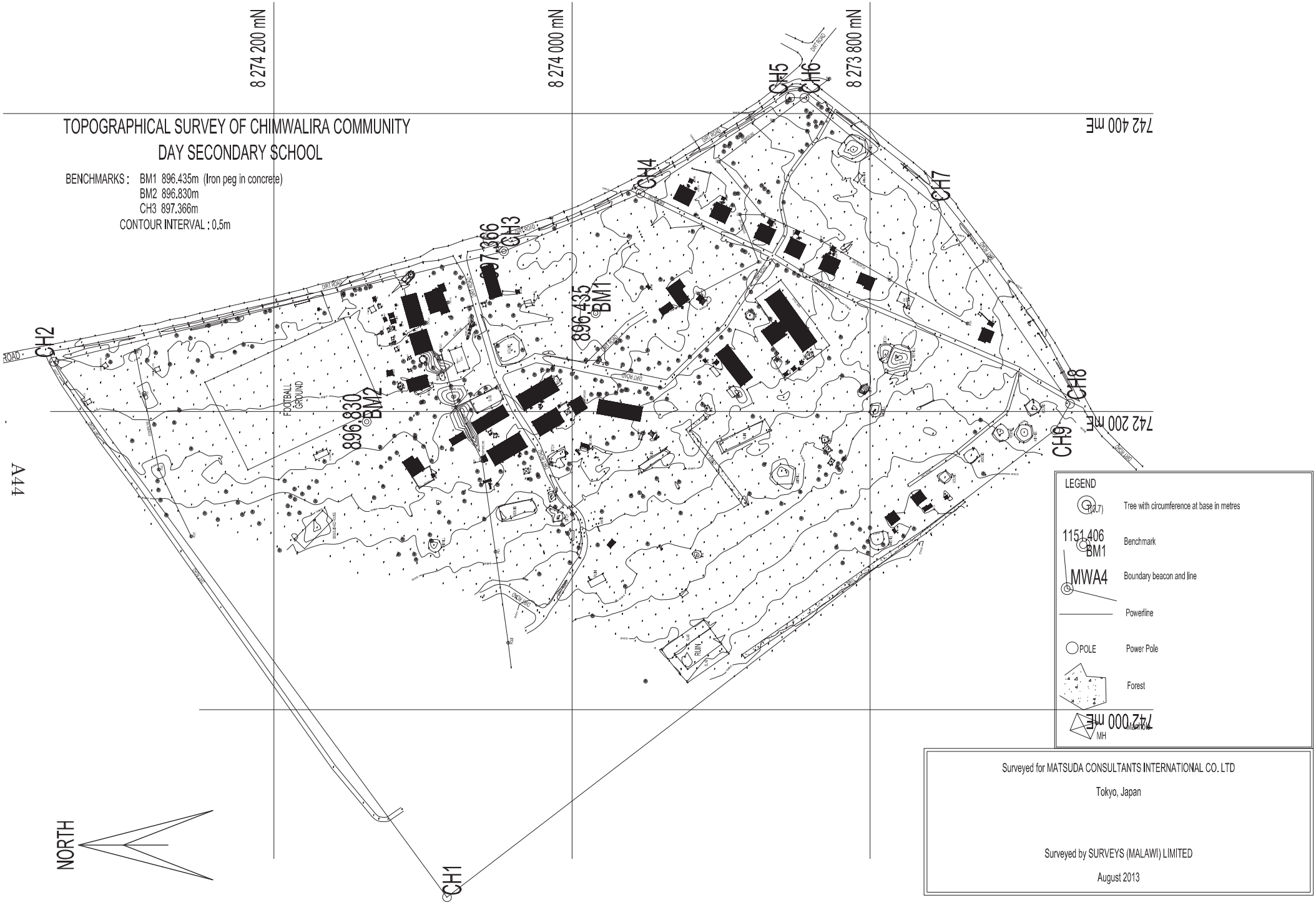
			APPROVED BY :	SCALE : 1:1500		

TOPOGRAPHICAL SURVEY OF CHIMWALIRA COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 896.435m (Iron peg in concrete)
BM2 896.830m
CH3 897.366m
CONTOUR INTERVAL : 0.5m



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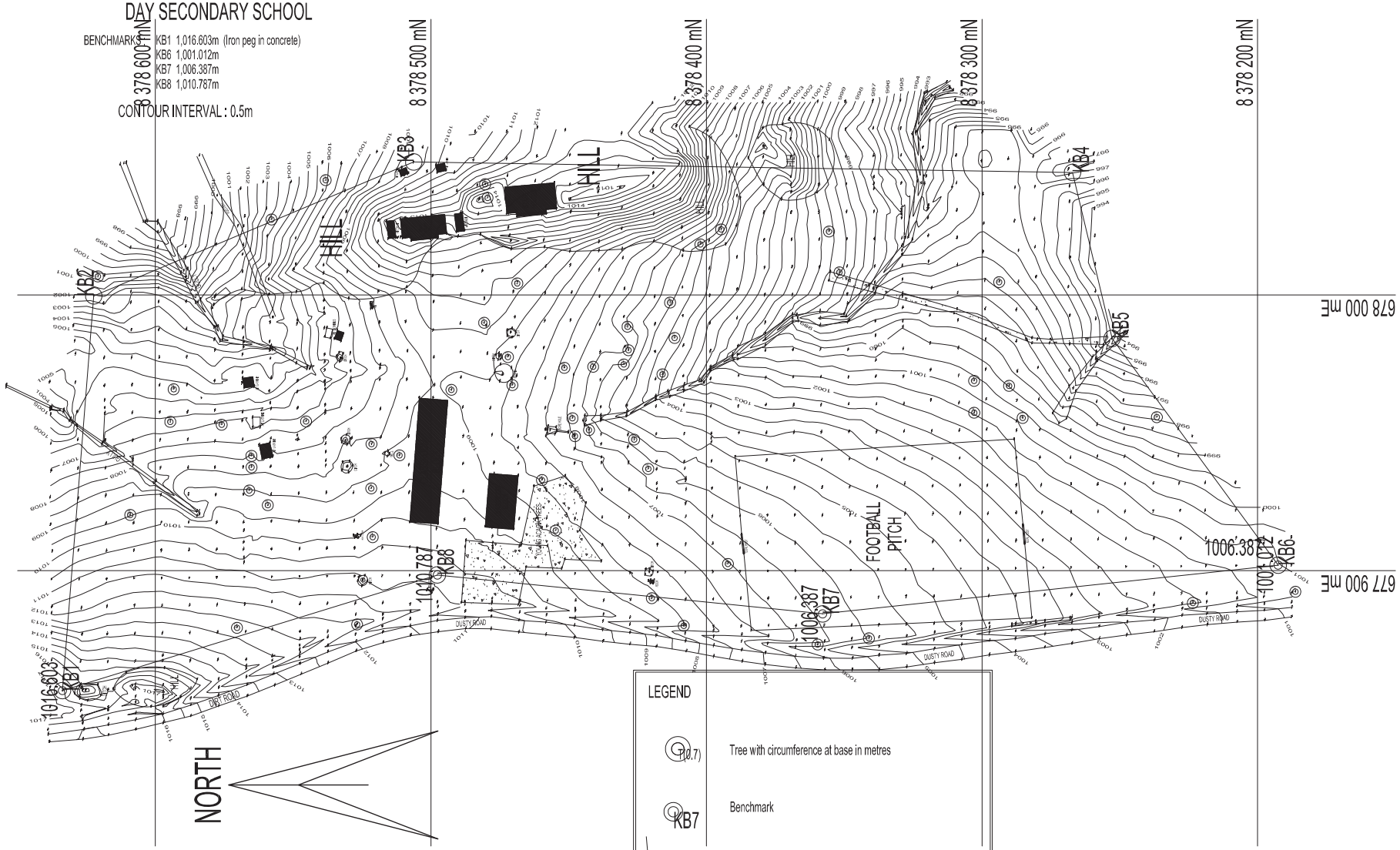
TOPOGRAPHICAL SURVEY OF KABEKERE COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS KB1 1,016.603m (Iron peg in concrete)
KB6 1,001.012m
KB7 1,006.387m
KB8 1,010.787m

CONTOUR INTERVAL : 0.5m



A45

LEGEND

- (10.7) Tree with circumference at base in metres
- KB7 Benchmark
- KB4 Boundary beacon and line
- Forest

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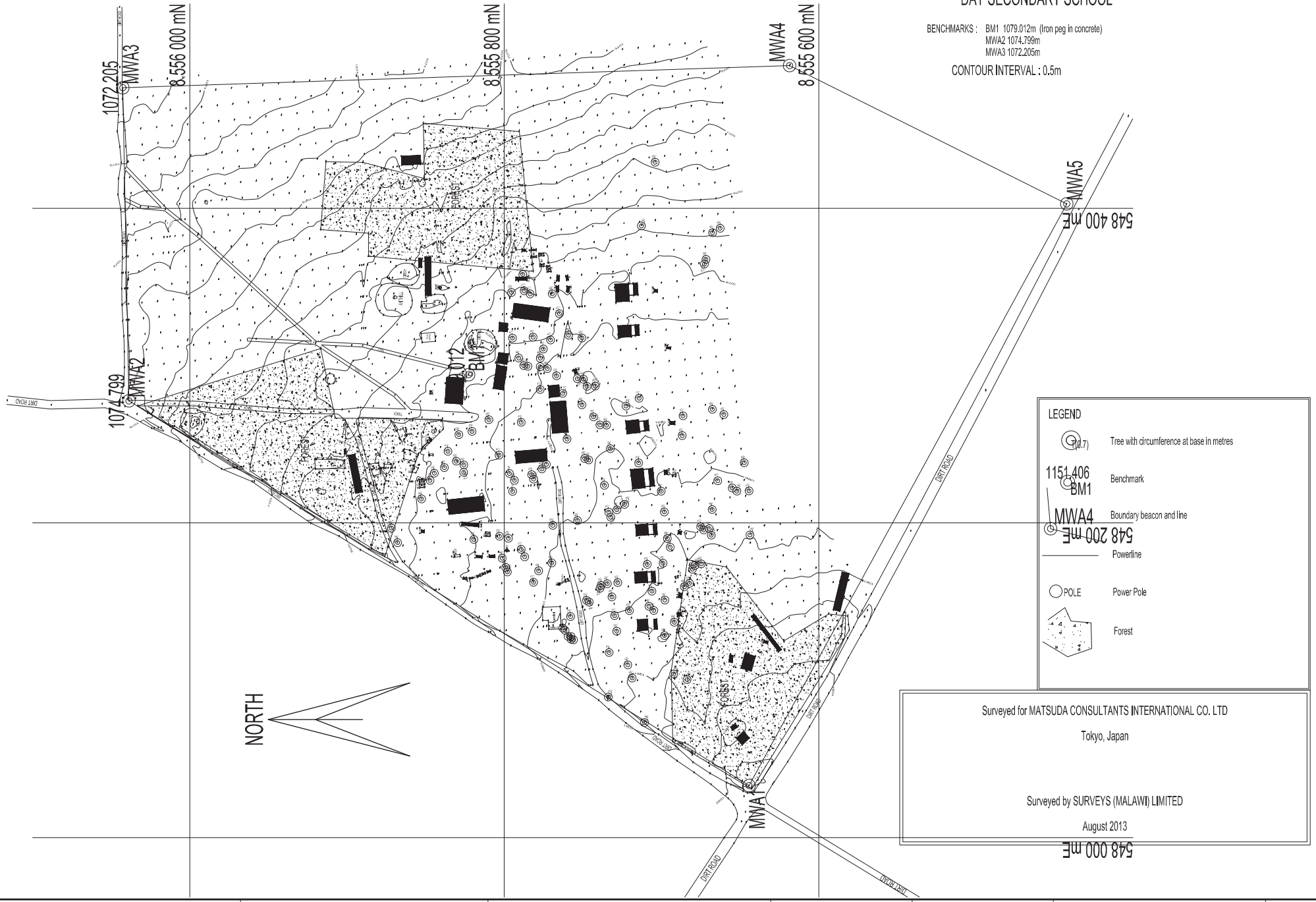
TOPOGRAPHICAL SURVEY OF MWALAWANYENJE COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 1079.012m (Iron peg in concrete)
MWA2 1074.799m
MWA3 1072.205m

CONTOUR INTERVAL : 0.5m



LEGEND

- (0.7) Tree with circumference at base in metres
- 1151.406 BM1 Benchmark
- MWA4 Boundary beacon and line
- Powerline
- POLE Power Pole
- Forest

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Surveyed by SURVEYS (MALAWI) LIMITED

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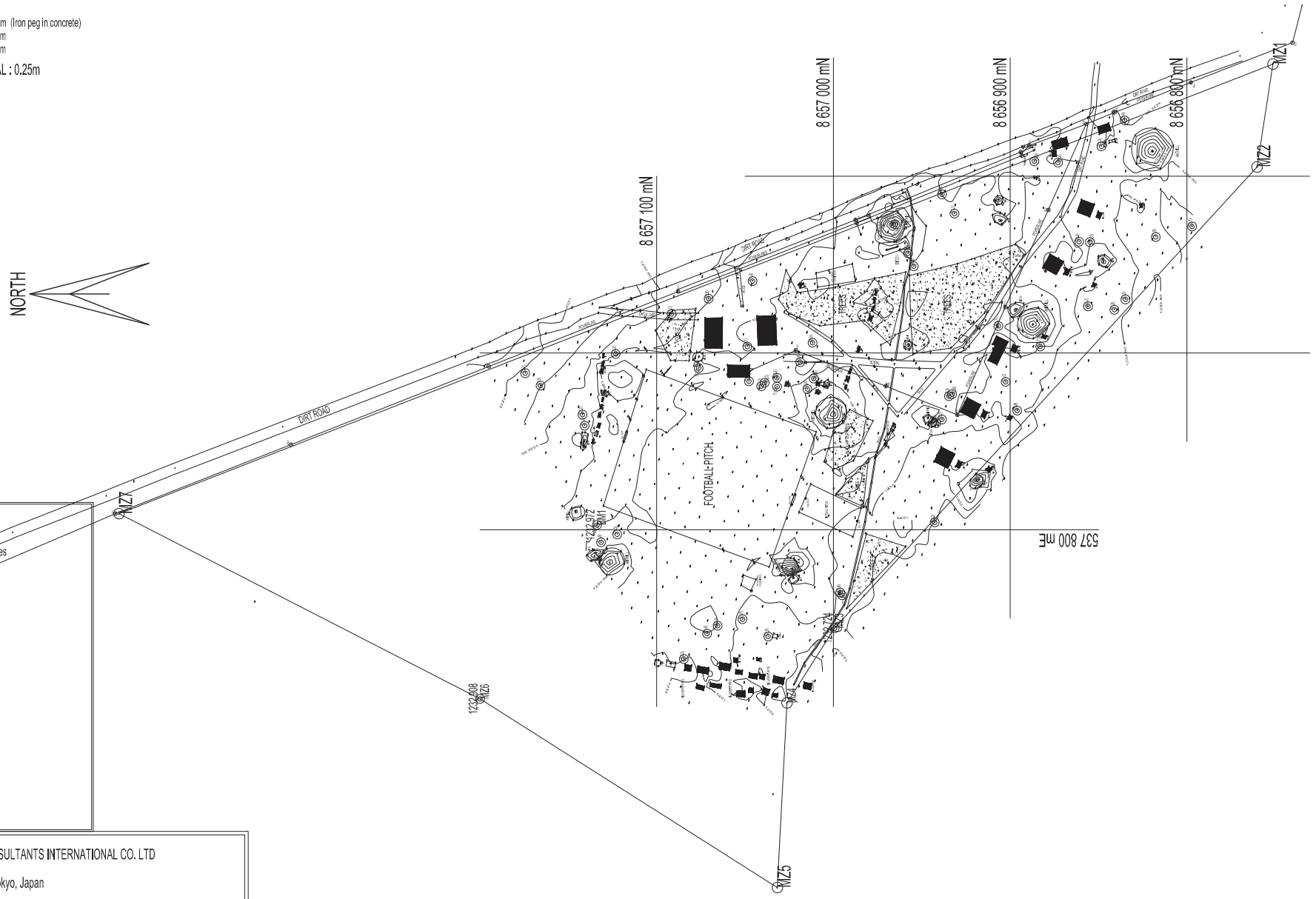
			APPROVED BY :	SCALE : 1:1500		

TOPOGRAPHICAL SURVEY OF MZOMA COMMUNITY DAY SECONDARY SCHOOL

BENCHMARKS : BM1 1232.972m (Iron peg in concrete)
MZ3 1232.724m
MZ6 1232.908m

CONTOUR INTERVAL : 0.25m



A47

LEGEND

- (Ø0.7) Tree with circumference at base in metres
- 1151.406 BM1 Benchmark
- MWA4 Boundary beacon and line
- Powerline
- POLE Power Pole
- Forest

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			APPROVED BY :	SCALE : 1:1500		

THE POLYTECHNIC
CIVIL ENGINEERING DEPARTMENT

REPORT ON GEOTECHNICAL INVESTIGATIONS ON CHIMWALIRA CDSS IN ZOMBA, KABEKERE CDSS IN NTCHEU DISTRICT, MUHASUWA CDSS IN CHIRADZULU, UMBWI SS IN DEDZA AND ZOMBA URBAN CDSS IN ZOMBA CITY

TO: MATSUDA INTERNATIONAL CONSULTANTS

PREPARED BY: TUTULE MSUKWA, MPhil, BSc Civil Eng, Reng.
Geotechnical Engineer

SEPTEMBER 2013

Table of Contents

1.0 INTRODUCTION

1.1 General

Matsuda International Consultant contacted Malawi Polytechnic, Civil Engineering Department to conduct geotechnical investigations and recommend appropriate bearing capacity of structures on various sites in Malawi, namely; Chimwalira CDSS (Community Day Secondary School), Kabekere CDSS in Ntcheu, Muhasuwa CDSS in Chiradzulu, Umbwi SS (Secondary School) in Dedza and Zomba Urban CDSS in Zomba.

Site reconnaissance, insitu testing and soil sampling for all the sites were carried out from 1st August 2013 to 31st August 2013. Laboratory testing proceeded immediately at the Malawi Polytechnic Laboratory in Blantyre.

1.2 Project Description

It is our understanding that the project involves the construction of new standard classroom blocks, administration blocks, multipurpose hall, laboratory blocks, toilets, hostels and staff houses in the selected CDSS and SS. From our knowledge of schools structures in Malawi it is our understanding that the structures to be built will be ground level structures with no storeys and that the structures will be mainly load bearing walls resting on standard mass concrete strip footings.

1.3 Objectives of the Soil Investigation

The purpose of the geotechnical exploration exercise was to:

1. To determine the subsoil conditions under the proposed sites for the construction of blocks.
2. To determine the engineering properties of the subsoil.
3. To comment on the type of foundation to be adopted.
4. To assess the bearing capacity of the soil in line with standard strip footings of width 690mm.

2 Soil Sampling and Testing

In all there were five sites. In all the sites, trial pits were dug in order to reveal the soil profile, carry out insitu tests and get samples for laboratory testing. Location for trial pits were agreed with Matsuda Consultants. The trial pits were approximately 2.5 metres deep.

Insitu tests carried out, were Water Penetration test (WPT) and Dynamic Cone Penetration Test (DCP). The soil samples recovered from the trial pits were taken to the Polytechnic laboratory, and examined to confirm the field descriptions. Representative samples were then selected for classification tests (plasticity and grading test) and specific gravity tests. Where possible undisturbed samples for triaxial testing were collected.

2.1 Chimwalira CDSS

Six trial pits for sample collection and testing evenly distributed were dug at Chimwalira CDSS. In addition three more pits were dug for Water penetration test. Furthermore 37 points were selected for DCP testing.

Observations on trial pits at 2m to 3m depth and classification tests indicated that the soils were alternating between light red stiff non plastic sandy gravels soils to decomposed light red rock dominated by gravelly sand.

From the triaxial test, the worst case scenario was observed on Pit no. 3 which gave an angle of friction of 8.3 degrees and cohesion intercept of 100kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 850kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 425kN/m^2

From the DCP test it was observed that most surface areas had Penetration Index (PI) of less than 10mm/blow (approx CBR of 22). Highest amount of penetration index were observed on very few pits (15mm/blow, approximately a CBR of 13) on depth of around 1m. This indicates that averagely Chimwalira CDSS has a quite strong and stable ground condition which can ably accommodate normal foundation loads from buildings. In areas where the PI is greater than 20mm/blow, the areas can be recompacted to improve their bearing capacity or otherwise they can be avoided.

The water penetration results gave an average percolation value of 2.67mm/min which is adequate for soakaways.

2.2 Kabekere CDSS

Six trial pits for sample collection and testing were dug at and around Kabekere CDSS. In addition three more pits were dug for Water penetration test. Furthermore 48 points were selected for DCP testing.

Observations on trial pits at 1 to 3m depth and classification tests indicated that the soils basically ranged from very firm light red non plastic sandy soils with traces of gravels near the surface and decomposed to slightly decomposed light reddish to grey rock beyond 1m which was difficult to cultivate.

Due to the nature of the soils triaxial tests were not possible. From observation and literature, a safe bearing capacity of 150kN/m^2 can be adopted for 690mm footing beyond a depth of 1m.

From the DCP test it was observed that most areas had a Penetration index of less than than 12.5mm/blow (approx CBR of 16.6). This indicates that basically the surface at Kabekere CDSS is stable and strong , foundations can ably be put at any depth beyond 1m from the ground.

The water penetration results gave an average percolation value of 3.94mm/min which is quite good for soakaways.

2.3 Muhasuwa CDSS

Six trial pits for sample collection and testing were dug at and around Muhasuwa CDSS. Water penetration test was carried out in three pits. Results were realised in two pits only because the third pit could not hold water, i.e the permeability was high. 47 points were selected for DCP testing.

Observations on trial pits at 1m to 2m depth and classification tests indicated that the soils were basically dark red stiff red clayey sands of low plasticity with traces of gravel. Beyond 2m presence of slightly decomposed rock was observed in most of the pits.

From the triaxial test, the worst case scenario was observed on Pit no. 1 which gave an angle of friction of 7.3 degrees and cohesion intercept of 81kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 638kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 319kN/m^2.

From the DCP test it was observed that most areas had a Penetration index of less than 18mm/blow (approx CBR of 10.4). This indicates that basically the surface of Muhasuwa is stable and sound to withstand foundation loads from buildings such as school blocks. Foundations can ably be put at depth of more than 1m.

The water penetration results gave an average percolation value of 3.3mm/min which is quite good for soakaways

2.4 Umbwi Secondary School

Six trial pits for sample collection and testing were dug at and around Umbwi SS. In addition three more pits were dug for Water penetration test. Water penetration test was carried out in

three pits. Results were realised in two pits only because the third pit could not hold water, i.e the permeability was high. Furthermore 26 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically red sandy clays of Intermediate plasticity with some traces of gravel size particles size.

From the triaxial test, the worst case scenario was observed on Pit no. 6 which gave an angle of friction of 8.6 degrees and cohesion intercept of 43kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 340kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 170kN/m^2.

From the DCP test it was observed that most areas had a Penetration index of less than 16mm/blow (approx CBR of 12.1). This indicates that basically the surface at Umbwi SS is stable and sound. Foundations can safely be placed at depth of not less than 1m from the surface.

The water penetration results gave an average percolation value of 3.05mm/min which is adequate for soakaways.

2.5 Zomba Urban CDSS

Six trial pits for sample collection and testing were dug at and around Zomba Urban CDSS. . In addition three more pits were dug for Water penetration test. 46 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically red silty sands of intermediate plasticity at depth of less than 1m followed by decomposed to slightly decomposed rocks at advancing depth.

From the triaxial test, the worst case scenario was observed on Pit no. 2 which gave an angle of friction of 9 degrees and cohesion intercept of 80kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 754kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 377kN/m^2

From the DCP test it was observed that most areas had a Penetration index of less than 15mm/blow (approx CBR of 13.1). This indicates that basically the surface at Zomba CDSS is stable and sound. Foundations can safely be placed at depth of not less than 1m from the surface.

The water penetration results gave an average percolation value of 1.6mm/.

2.6 Mlodza CDSS

Six trial pits for sample collection and testing were dug at and around Mlodza CDSS. In addition three more pits were dug for Water penetration test. Furthermore 73 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically reddish stiff gravelly clays of Intermediate plasticity with traces of sand size particles.

From the triaxial test, the worst case scenario was observed on Pit no. 3 which gave an angle of friction of 8. degrees and cohesion intercept of 68kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 544kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 272kN/m^2 which is adequate to support foundation loads from the buildings.

From the DCP test it was observed that most areas had a Penetration index of less than 14mm/blow (approx CBR of 14.4). This indicates that basically the surface at Mlodza CDSS is stable and sound. Foundations can safely be placed at depth of not less than 1m from the surface.

The water penetration results gave an average percolation value of 1.7mm/min

2.7 Mwatibu CDSS

Six trial pits for sample collection and testing were dug at and around Mwatibu CDSS. In addition three more pits were dug for Water penetration test. Furthermore 73 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically greyish stiff clays of Intermediate plasticity with presence of gravel and sand size particles beyond 2m a decomposed rock could be noticed.

From the triaxial test, the worst case scenario was observed on Pit no. 5 which gave an angle of friction of 9.6 degrees and cohesion intercept of 66kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 538kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 269kN/m^2 which is adequate to support foundation loads from the buildings.

From the DCP test it was observed that most areas had a Penetration index of less than 13mm/blow (approx CBR of 15.8). This indicates that basically the surface at Mwatibu CDSS is stable and sound. Foundations can safely be placed at depth of not less than 1m from the surface.

The water penetration results gave an average percolation value of .83mm/min.

2.8 Mwalawanyenje CDSS

Six trial pits for sample collection and testing were dug at and around Mwalawanyenje CDSS. In addition three more pits were dug for Water penetration test. Results of penetration test were not realised because the water seeped away. Furthermore 46 points were selected for DCP testing.

Observations on trial pits at less than 2m depth and classification tests indicated that the soils were predominantly reddish silty sands of Intermediate plasticity with traces of gravel size particles. Beyond 2m a decomposed rock was noted.

From the triaxial test, the worst case scenario was observed on Pit no. 6 which gave an angle of friction of 8.5 degrees and cohesion intercept of 57kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 438kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 219kN/m^2 which is adequate to support foundation loads from the buildings.

From the DCP test it was observed that some of the areas had a Penetration index of less than 30mm/blow (approx CBR of 5.5). This indicates that basically most of the surface at Mwalawanyenje CDSS is weak. Before the foundation can be placed the foundation area need to be treated by placing at least a 200mm layer of compacted gravel to 98% MDD. This will assist to bridge up weak areas.

2.9 Mzoma CDSS

Six trial pits for sample collection and testing were dug at and around Mzoma CDSS. In addition three more pits were dug for Water penetration test. Results of penetration test were not realised because the water seeped away. Furthermore 46 points were selected for DCP testing.

Observations on trial pits at less than 2m depth and classification tests indicated that the soils were predominantly reddish slightly clayey sands of Intermediate plasticity with traces of gravel size particles on pit 1 and 2 to non plastic red sandy gravels. On pits 3, 4, 5 and 6.

From the triaxial test, the worst case scenario was observed on Pit no. 2 which gave an angle of friction of 8.6 degrees and cohesion intercept of 60kN/m^2. Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 478kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 239kN/m^2 which is adequate to support foundation loads from the buildings.

From the DCP test it was observed that most areas had a Penetration index of less than 13mm/blow (approx CBR of 15.8). This indicates that basically the surface at Mzoma CDSS is stable and sound. Foundations can safely be placed at depth of not less than 1m from the surface.

The water penetration results gave an average percolation value of 4mm/min which is adequate for soakaways.

2.10 KABWABWA CDSS

Six trial pits were dug at and around Kabwakabwa CDSS for sample collection and testing.

In addition, three more pits were dug for water penetration test [wpt].Furthermore, 41 points were selected for DCP testing. Observations on trial pits at 1m to 3m depth and classification tests indicated that the soils basically ranged from very firm grayish non plastic sandy soils with traces of gravel near the surface and decomposed to slightly decomposed light grey rock beyond 1m which was difficult to excavate with a pick. Due to the nature of the soils, triaxial test were not possible .From observation and literature,a safe Bearing capacity of 150KN/M2 can be adopted for a 690mm footing beyond a depth of 1m. From DCP test. It was observed that most of the area had a penetration index of less than 7.9mm/blow [approx CBR of 30].This shows that the surface at Kabwabwa CDSS is stable and strong which implies that the foundation can ably be put at any depth beyond 1m from the ground. The water penetration test [wpt] were not realized on all the three pits because water seeps away within a period of 10mins, an indication of high permeability.

2.11 M'BINZI CDDS

Again six trial pits for sample collection and testing were dug at and around M'binzi cdss.In addition, three more pits were dug for water penetration test [wpt]. Furthermore ,55 points were selected for DCP testing. Observations on trial pits at 1m to 3m depth and classification tests indicated that the soils at M'binzi basically ranged from very firm light grey no plastic sandy soils with minor traces of gravel near the surface to slightly decomposed grey rock beyond 1.2m which was difficult to excavate with a pick.

Due the nature of the soils ,Triaxial tests were impossible.From literature and observation a Safe bearing capacity of 150KN/M2 can be adopted for a 690 mm footing beyond a depth of 1m. The water penetration test [wpt] were not realized on two of the three test pits because water seeps away within 10 mins.On the third pit, the percolation value of 3.6mm/min was realized,which is adequate for soakways.

From the DCP test,it was observed that most of the area had a penetration index of less than 10.2mm/blow [approx CBR of 22].This also shows that the surface at M'binzi cdss is strong

and stable. The DCP results 1mplies that foundation can ably be put at any depth beyond 1m from the surface.

3 RECOMMENDATIONS

The bearing capacity of the soils for a 690mm wide foundation for all the CDSS and SS are in excess of 150kN/m2 which is adequate to support loads from blocks having a foundation 690mm wide. In addition the PI in all the areas was less 18mm/blow indicating a quite stable ground capable of supporting non storey building blocks. Again the soil conditions (through observations) and the difficulties in excavating the pits using picks also indicates that the soils are strong.

4 References

1. Soil mechanics by R.F. Graig
2. Elements of Soil mechanics by G.N. Smith

5.0 Appendices

1. Classification Test results
2. Triaxial Test Results
3. DCP Test results
4. Water penetration test Results

To be attached later